

3. WATER REQUIREMENTS

A water utility supplies water to meet its user's demands at flow rates that fluctuate yearly, monthly, daily, and hourly. Water demands are typically higher during dry years and in hot months. Water demand follows a diurnal (daily) pattern that is generally low at night and high in the early morning and late in the day. The most significant demands in the design and operations of a water system are the annual Average Day (AD), the Maximum Day (MD) and the Maximum Hour (MH) demands.

Average day demand is defined as the total annual water pumped to distribution divided by the number of days in the year. The average day demand is utilized in estimating future average day, future maximum day, and future maximum hour demands. The average day demand is used to determine the required yield of water supply sources and used indirectly in determining estimated future revenues and operating costs.

Maximum day demand is defined as the largest quantity of water pumped to distribution on any one day during the year. The maximum day demand is utilized in sizing most water supply and treatment facilities.

Maximum hour demand is defined as the largest quantity of water pumped to distribution, adjusted for any inflow and outflow from system storage, in any one-hour period during the year. Since minimum distribution system pressures are commonly experienced during the maximum hour, the sizes and locations of distribution facilities are determined considering maximum hour conditions. Maximum hour demands are met using strategically located system storage. The use of system storage minimizes the required capacity of the treatment facilities, the water transmission mains, and the pumping facilities. It also results in a more uniform and economical operation of the water system as a whole.

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A. HISTORICAL WATER USE

1. Historical System Water Use and Peaking Factors

The annual average day, maximum day, and maximum hour water demands for the period 1985 through 2001 are summarized in Table 3-1. The ratios of maximum day demand to the average day demand (MD/AD) and the maximum hour demand to average day (MH/AD) demand also are listed in the table.

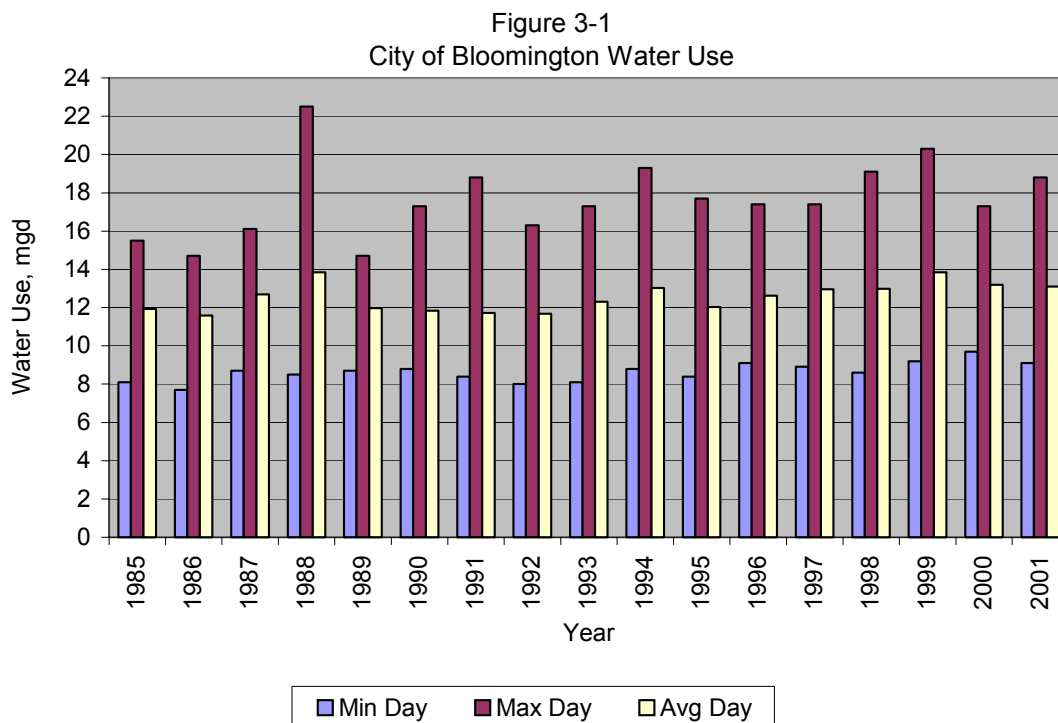
Table 3-1 Historical Water Demands and Peaking Factors					
Year	Water Demand, mgd			Peaking Factors	
	Average Day	Maximum Day	Maximum Hour	MD/AD Ratio	MH/AD Ratio
1985	11.93	15.50	17.50	1.30	1.47
1986	11.58	14.70	18.20	1.27	1.57
1987	12.69	16.10	18.30	1.27	1.44
1988	13.84	22.50	24.40	1.63	1.76
1989	11.98	14.70	17.60	1.23	1.47
1990	11.83	17.30	17.30	1.46	1.46
1991	11.72	18.80	21.20	1.60	1.81
1992	11.68	16.30	21.90	1.40	1.87
1993	12.31	17.30	17.70	1.41	1.44
1994	13.03	19.30	20.70	1.48	1.59
1995	12.03	17.70	22.70	1.47	1.89
1996	12.62	17.40	22.30	1.38	1.77
1997	12.96	17.40	22.90	1.34	1.77
1998	12.98	19.10	24.00	1.47	1.85
1999	13.85	20.30	24.80	1.47	1.79
2000	13.19	17.30	23.50	1.31	1.78
2001	13.09	18.80	22.90	1.44	1.75
Average Peaking Factor				1.41	1.68
Largest Peaking Factor				1.63	1.89
Smallest Peaking Factor				1.23	1.44
Peaking Factors Used for Design				1.60	1.90

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Table 3-1 shows that during the period 1985 through 2001, the largest ratio of maximum day to average day (MD/AD) water demand was 1.63. From experience, for medium-sized communities with populations between 20,000 to 75,000 have their largest MD/AD ratio in the range of 1.30 to 1.75. CBU's ratio of 1.63 is in the typical range for medium sized communities. Larger communities or communities with large industrial water use commonly have their largest MD/AD ratio in the range of 1.20 to 1.60. Affluent, rapidly growing systems where lawn irrigation is practiced extensively can have MD/AD ratios as high as 2 or 3. The largest MD/AD ratio for the CBU system is only slightly higher than the commonly largest MD/AD ratio. Since university students account for approximately 65 percent of the City's population while school is in session, the water use pattern of the university students greatly influences the City's water demand ratios. During the summer, the student population decreases dramatically, which reduces demands during the typical high use summer period. After reviewing the data listed in Table 3-1, it was determined that 1999 was the best (most conservative) year to use in establishing system-wide demands. The MD/AD factor of 1.60 was used for design purposes.

Figure 3-1, which follows, illustrates a slightly rising trend in average day demands for the CBU system over the past seventeen years. During this time, the average day demand increased approximately 20 percent or 1.2% per year.

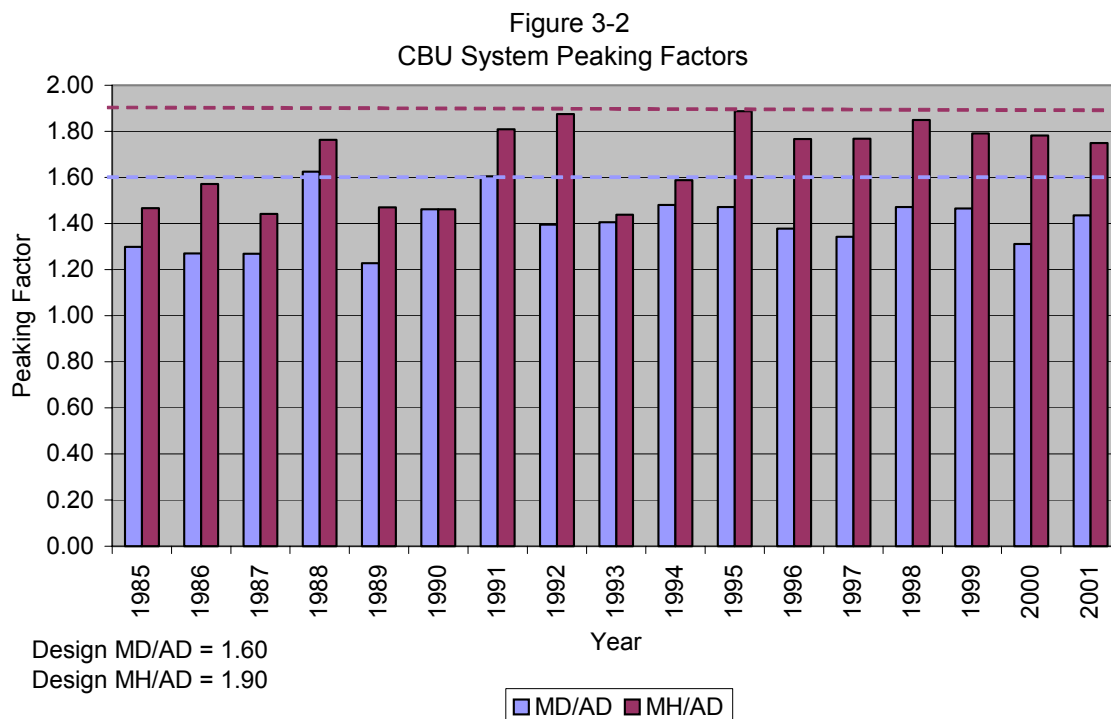
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Experience has shown that the largest ratio of the maximum hour to average day (MH/AD) water demand is typically 1.1 to 1.5 times the largest maximum day to average day ratio (MD/AD). Applying these experienced factors to CBU's 1.63 largest MD/AD ratio gives a MH/AD ratio of 1.8 to 2.4. In the seventeen years listed in Table 3-1, the largest ratio for MH/AD was 1.89 and is consistent with experience. Since 1999 was the more conservative year to use in establishing system-wide demands, the MH/AD factor of 1.90 was used for design purposes.

In the following Figure 3-2, the peaking factors for maximum day and maximum hour water demands from 1985 through 2001 are shown. The peaking factors used in projecting future water requirements for design are consistent with conditions historically experienced by CBU.

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A risk analysis was performed to determine the appropriate return period desired for peaking factor development for maximum day and maximum hour demands, and to aid in understanding the implications of these factors. If a water system improvements program is planned based on subjectively low design peaking factors, it would be anticipated that the future peak demands would exceed the capacity of the system, and water restrictions would need to be imposed too often. Conversely, if an improvements program is planned based on high peaking factors, the additional and premature cost of capital improvements may not be warranted. The return period of historical peaking factors was evaluated to aid in the selection of peaking factors used for water demand projections.

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Frequency distribution plots were prepared using the data in Table 3-1 and are shown on Figures 3-3 and 3-4. The figures show the percent probability of a peaking factor being exceeded, based on historical data. The figures also show the design peaking factors used for this study. As indicated previously, for design purposes, a MD/AD ratio of 1.60 and a MH/AD ratio of 1.90 was used. As shown in Figure 3-3, the selected MD/AD factor represents a return period of 9 years. Statistically, based on a 9-year return period, the risk of being exceeded in any year would be approximately 11%. As shown in Figure 3-4, the MH/AD factor represents a return period of 20 years and statistically the risk of being exceeded in any year would be 5%.

Other return rates were considered, but developing facilities that have a lower return rate (frequency less than once every 10 years) cause a significant increase in system costs, without providing a corresponding increase in distribution system reliability. If the peak period water use exceeds the projected needs, then low-pressure problems in some localized areas water use may result. Those problems are dealt with more appropriately using water restrictions than by expensive distribution system improvements. Typically a 10-year return is desired, however, a 9-year return is considered acceptable.



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Fig 3-3



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Fig 3-4

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Total water pumped, population, and water use per capita per day from 1985 through 2000 are presented in Table 3-2. Overall, water use has been relatively constant over the past 15 years. Although the population increased from 1990 to 1995, the amount of water used per capita decreased. Since 1995, water use per capita has increased to about the same as it was in 1985.

Table 3-2 Water Use Per Capita			
Year	Total Water Pumped, gallons	Population	Water Use^a, gal/capita/day
1985	3,946,692,000	56,338	192
1990	4,317,950,000	60,633	195
1995	4,398,500,000	64,962	185
2000	4,818,000,000	69,291	190
a. Includes residential, ICI, Indiana University, wholesale, and unaccounted-for water use			

2. Residential, ICI, Indiana University, and Wholesale Water Sales

System water use for residential, commercial, and wholesale have steadily increased at a moderate rate over the last several years. This has been due to the combined affect of new residential, commercial, and some minor expansion of the wholesale service area. Actually, the industrial component of the Industrial/Commercial/Institutional (ICI) user class has decreased. It is anticipated that CBU's water demands will continue to increase at a similar rate for the foreseeable future. Residential, ICI, Indiana University (IU), and wholesale water use for the years 1990 through 2001 are presented in Table 3-3, which follows.

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Table 3-3 System-wide Residential, ICI, Indiana University, and Wholesale Water Use									
Year	Residential ^{a,b}		ICI ^{a,c}		Indiana University (IU) ^{a,d}		Wholesale ^a		Total Water Use
	MG	%	MG	%	MG	%	MG	%	MG
1990	895	23	2,103	34	768	20	902	23	3,899
1991	1,000	24	2,284	33	877	21	957	23	4,241
1992	941	24	2,102	33	764	19	957	24	3,899
1993	972	24	2,126	33	760	19	991	24	4,241
1994	1,063	25	2,258	33	811	19	1,008	23	4,038
1995	1,093	26	2,045	30	807	19	1,003	24	4,116
1996	984	23	2,195	34	762	18	1,034	25	4,357
1997	1,587	34	2,000	27	727	16	1,090	23	4,696
1998	1,692	38	1,680	22	700	16	1,069	24	4,419
1999	1,843	38	1,974	32	416	9	1,062	22	4,869
2000	1,615	37	1,656	31	320	7	1,040	24	4,294
2001	1,678	38	1,703	29	413	9	1,014	23	4,394
a. Percent of Total Residential, ICI, IU, and Wholesale water sales. b. Residential does not include Indiana University on-campus housing. c. ICI includes Industrial, Commercial, and Institutional (with the exception of IU) categories. d. University water use is understated for years 1999, 2000, and 2001.									

a. Residential Metered Water Use

Residential water use is currently about 38 percent of the total water used. As presented in Table 3-3, the percentage of residential water use has increased steadily over the past twelve years from a low of around 23 percent in 1990 to nearly 40 percent in 2001.

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Residential use consists of water used by domestic customers in single-family dwellings and duplexes. Residential use does not include Indiana University on-campus housing, such as sororities, fraternities, campus apartments, and campus real estate.

b. ICI and Indiana University Metered Water Use

Excluding Indiana University, the percentage of water used by ICI customers averaged about 30 percent of the total water use. As shown in Table 3-3, the percentage of ICI water use has steadily decreased from a high of around 35 percent in 1990 to nearly 30 percent in 2001. The decrease in water use is attributed to the City's loss of several industrial customers.

The percentage of water used by Indiana University averaged about 15 percent of the total water use. The water used since 1999 is considerably lower than in previous years. CBU indicated that this was attributed to meters that were not read.

CBU's industrial customers include large industries such as General Electric and Otis Elevator. Commercial and institutional use consists of water used by apartment complexes, hotels, businesses, schools, hospitals, and similar establishments. Metered water use for the top 35 retail customers for January through September of 2002 is summarized in Table 3-4. These 35 large users represent about 65 percent of the total ICI sales, including Indiana University.

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Table 3-4 Top 35 Retail Water Users for 2002			
No.	Customer	Total Water Use, MG	Average Water Use, mgd
1	Indiana University	475	1.741
2	Bloomington Hospital	45	0.163
3	General Electric	27	0.100
4	Baxter Pharmaceutical	27	0.097
5	Cook, Inc.	15	0.055
6	Capstone Development Corp.	15	0.053
7	Bloomington Country Club	14	0.050
8	R H S Water Corp.	13	0.049
9	City of Bloomington Parks and Recreation	12	0.045
10	Woodbridge Apartments III	12	0.045
11	Arlington Valley Mobile Home LLC	12	0.044
12	Irving Materials, Inc.	11	0.042
13	Regency Fountain Park Apartments	11	0.041
14	Fontanbleu Nursing Center	9	0.033
15	Heatherwood Park Mobile Est.	8	0.030
16	Monroe County Community School Corp.	8	0.029
17	Southcrest Mobile Home Manor	7	0.027
18	Basswood LLC	7	0.027
19	Monroe County Commissioners	7	0.025
20	Regency Meadow Park Apartments	6	0.022
21	Meadowood Retirement Community	5	0.019
22	Schulte Corp.	5	0.018
23	Rolling Ridge Apartments	5	0.018
24	Robert Eads	5	0.018
25	Henderson Courts	5	0.017
26	Otis Elevator Co.	4	0.016
27	Maple Court	4	0.015
28	Hyde Park Development	4	0.015
29	Garden Hills Mobile Home Park	4	0.015
30	Summit Pointe LLC	4	0.014
31	Bloomington Kinser Hotel Assn.	4	0.013
32	Bradford Ridge Apartments	4	0.013

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Table 3-4 Top 35 Retail Water Users for 2002			
No.	Customer	Total Water Use, MG	Average Water Use, mgd
33	FSF Woodland Springs Assn., LLC	4	0.013
34	Redbud Hills	3	0.012
35	Monroe County Parks and Recreation	3	0.010
Total		804	2.946

c. Wholesale Metered Water Use.

CBU's wholesale customers are primarily nearby rural water companies. The customers include B&B Water Project, Inc., East Monroe Water Corporation, Ellettsville Utilities, Town of Nashville, Southern Monroe Water Corporation, Van Buren Township, and Washington Township Water Corporation. Water is supplied to the wholesale customers through a series of master meters. Six of the seven wholesale water users have agreements with the City that contain language regarding the minimum and maximum quantities allowed.

Wholesale water use increased from about 900 MG in 1990 to 1,000 MG in 2000, as presented in Table 3-3. Wholesale water use has steadily grown and has amounted to nearly 25 percent of the total water use for the past ten years. Based on City billing information, water use by CBU's wholesale customers from 1997 through 2000 is shown in Table 3-5.

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Table 3-5 Wholesale Customer Water Use (1997-2000)							
Customer	Total Annual Water Use, MG					Annual Avg Use, mgd	Percent of Total Wholesale
	1997	1998	1999	2000	Avg		
B&B	114	108	118	118	114	0.31	10.7
East Monroe	162	124	99	125	128	0.35	12.0
Ellettsville	301	342	285	285	303	0.83	28.6
Nashville	40	24	8	16	22	0.06	2.0
Russell Rd. Water Corp.	9	11	7	NA	9	0.02	0.7
Shady Side Dr.	1	1	1	1	1	0.00	0.1
Southern Monroe	247	232	279	244	250	0.68	23.4
Van Buren Twp.	135	144	172	152	151	0.41	14.1
Washington Twp.	81	85	92	99	89	0.24	8.3
Total	1,090	1,069	1,062	1,040	1,067	2.90	100

3. Unaccounted-for Water.

Unaccounted-for water is the water lost in the system expressed as a percentage of the total volume of water pumped. It is determined by subtracting the metered water use in the system and the estimated unmetered water use from the volume pumped from the water treatment facilities. Unaccounted-for water is generally attributable to causes such as distribution system leakage, meter inaccuracies, unauthorized connections, water used by street sweepers, hydrant flushing, and fire fighting. The unaccounted-for water for the years 1990 through 2001 is summarized in Table 3-6. For the 12-year period, it ranged from a low of 0.85 percent to a high of 10.46 percent. The percentage of unaccounted-for water averaged 6.58 percent and met the American Water Works Association Leak Detection and Water Accountability Committee recommended goal of less than 10 percent.

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Table 3-6 Unaccounted-for Water				
Year	Water Treatment Plant High Service Pumping, mgd	Total Metered Sales, mgd	Unaccounted-for Water	
			mgd	Percent of Total Pumped
1990	11.83	10.68	1.15	9.69
1991	11.72	11.62	0.10	0.85
1992	11.68	10.96	0.72	6.16
1993	12.31	11.20	1.11	9.02
1994	13.03	11.86	1.17	8.98
1995	12.03	11.34	0.69	5.74
1996	12.62	11.54	1.08	8.56
1997	12.96	12.81	0.15	1.16
1998	12.98	12.17	0.81	6.24
1999	13.85	13.36	0.49	3.54
2000	13.19	11.81	1.38	10.46
2001	13.09	12.04	1.05	8.01
Average			0.83	6.58

B. WATER USE PROJECTIONS

Water use projections were developed for the total system for the base year (year 2000) and years 2010, 2020, and 2030. The base year water use represents the theoretical water use that would have occurred in year 2000, using the same criteria as for the projected water requirements.

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1. Total System Design Criteria

Historical water use and population projections were used to estimate the average water use on a per capita basis for residential customers for the base year 2000 and years 2010, 2020, and 2030. The average day residential water use was determined by multiplying the per capita water use by the population. The average day ICI, Indiana University, wholesale, and unaccounted-for water use was estimated on a proportional basis. The design criteria used for calculating the average day water requirements are summarized in Table 3-7.

Table 3-7 Design Criteria for Average Day Water Use Calculations				
Design Criteria	2000	2010	2020	2030
Population ^a	53,154	64,187	77,506	93,023
Base Residential Use ^b	85 gpcd	85 gpcd	85 gpcd	85 gpcd
Residential/ICI Ratio (%)	38/62	40/60	42/58	44/56
Unaccounted - for (%) ^c	10	10	10	10
MD/AD Ratio	1.60	1.60	1.60	1.60
MH/AD Ratio	1.90	1.90	1.90	1.90
a. The population shown is the residential population less IU on-campus housing occupants. b. The base residential use was determined by dividing the total residential water use of 4.5 mgd by 53,154 people (year 2000 population of 69,291 less IU on-campus housing population of 16,137). c. For design, it is typical to allow 10% for the unaccounted-for water. Even though CBU averages 6.5% unaccounted-for water, 10% was used for design calculations.				

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The average day water use by class is summarized in Table 3-8.

Table 3-8 Base Year and Projected Average Day Water Use by Class								
User Class	2000		2010		2020		2030	
	mgd	%	mgd	%	mgd	%	mgd	%
Residential	4.5	34	5.5	36	6.6	38	7.9	40
ICI	2.7	20	3.5	22	4.0	23	4.7	24
IU	1.8	14	1.8	12	1.8	10	1.8	9
Wholesale	2.9	22	3.0	20	3.2	19	3.4	17
Subtotal	11.9	90	13.8	90	15.6	90	17.8	90
Unaccounted-for	1.2	10	1.4	10	1.6	10	1.8	10
Total	13.1	100	15.2	100	17.2	100	19.6	100

The maximum day and maximum hour water use were determined by applying the MD/AD peaking factor of 1.60 and the MH/AD peaking factor of 1.90, respectively, to the average day water use. Although these peaking factors typically are used system-wide (i.e. assigning the same factor to each user class) to project future water requirements for design, assigning each user class its own factor was more appropriate. This is mainly due to the affect of residential water use on the distribution system as compared to other user classes.

The peaking factors for residential use are typically higher than the overall average and those for ICI, IU, wholesale, and unaccounted-for use are usually lower. Residential water use has a greater influence on the distribution system than any other user because of variations in use. Residential areas have increases in water usage due to watering the lawn, washing cars, and recreational uses. Industrial areas have flow patterns that repeat as manufacturing begins and ends each weekday. Also, it is anticipated that ICI, IU, wholesale, and unaccounted-for water will have limited growth. Therefore, their corresponding factors will be less than that used for residential.

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Peaking factors by class were calculated for the base year and each design year. The factors were adjusted slightly so that the sum of the water use would match the total system water use. The design peaking factors by class are summarized in Table 3-9.

Table 3-9 Design Peaking Factors by Class		
User Class	MD/AD	MH/AD
Residential	2.2	2.6
ICI	1.4	1.7
IU	1.2	1.4
Wholesale	1.2	1.4
Unaccounted-for	1.0	1.0
System-wide	1.6	1.9

Using the peaking factors shown in Table 3-9, the maximum day and maximum hour water demands by user class were determined for base year 2000 and design years 2010, 2020, and 2030 and are summarized in Table 3-10.

Table 3-10 Base Year and Projected Maximum Day and Maximum Hour Water Use by Class								
User Class	2000		2010		2020		2030	
	MD mgd	MH mgd	MD mgd	MH mgd	MD mgd	MH mgd	MD mgd	MH mgd
Residential	9.9	11.9	12.1	14.5	14.5	17.4	17.4	20.9
ICI	3.8	4.6	4.9	5.9	5.6	6.7	6.6	7.9
IU	2.2	2.6	2.2	2.6	2.2	2.6	2.2	2.6
Wholesale	3.5	4.2	3.6	4.3	3.8	4.6	4.1	4.9
Subtotal	19.4	23.3	22.8	27.3	26.1	31.3	30.4	36.3
Unaccounted-for water	1.2	1.2	1.4	1.4	1.6	1.6	1.8	1.8
Total	20.6	24.5	24.2	28.7	27.7	32.9	32.2	38.1

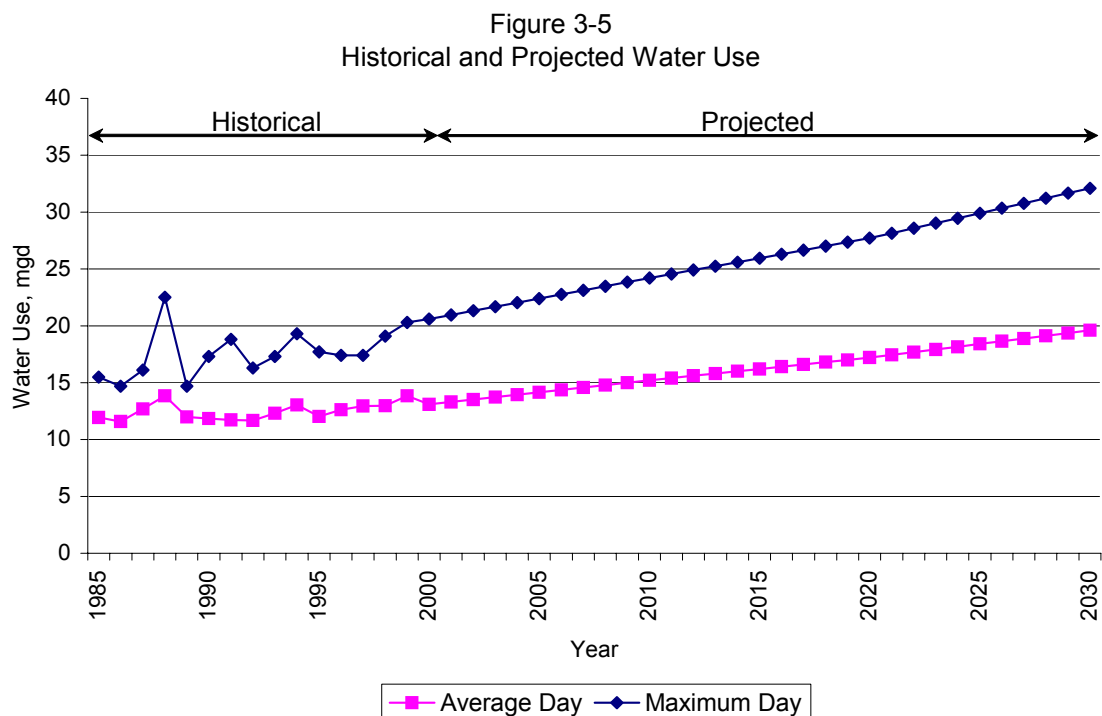
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A summary of the average day, maximum day, and maximum hour water use for the base year 2000 and design years 2010, 2020, and 2030 is presented in Table 3-11.

Table 3-11			
Projected Water Use			
Year	Average Day, mgd	Maximum Day, mgd	Maximum Hour, mgd
2000	13.1	20.6	24.5
2010	15.2	24.2	28.7
2020	17.2	27.7	32.9
2030	19.6	32.2	38.1

The historical and projected average day and maximum day water use for the CBU system are shown on Figure 3-5.

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C. FIRE FLOW REQUIREMENTS

To establish appropriate fire insurance premiums for residential and commercial properties, the Insurance Services Office (ISO) needs reliable, up-to-date information about a municipality's fire protection services. The ISO collects information on a community's public fire protection, analyzes the data, and assigns a public protection classification number between 1 and 10. Class 1 represents the best public protection, and Class 10 indicates less than the minimum recognized protection.

To determine the public protection classification, the ISO evaluates the water supply system. This includes the supply capacity for each pressure zone, treatment facilities, transmission facilities, and storage. Also included are such

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items as the condition and maintenance of hydrants, and the amount of available water compared with the amount needed to suppress fires.

The ISO calculates the needed fire flow for selected locations, determines the water-flow capabilities at those locations, and calculates a ratio considering the need and the availability. The ratio is then used in calculating credit points. The needed fire flow for an individual building is based on the building's area, construction, occupancy, and exposure. To obtain full credit, the water supply must be able to deliver water at 20 psi and at the specified rate of flow for a specified period of time. Needed fire flows for individual buildings range from a minimum of 500 gpm to a maximum of 12,000 gpm.

The ISO determines the needed fire flows for residential areas with one- and two-family dwellings by considering the distance between buildings as listed in Table 3-12.

Table 3-12	
Needed Fire Flow for Residential Areas	
Distance, feet	Needed Fire Flow, gpm
≤ 10	1,500
11 to 30	1,000
31 to 100	750
>100	500

The ISO does not consider the needed fire flow at certain high-demand properties in the public protection classification. Those properties include buildings graded and coded by the ISO as protected by an automatic sprinkler system meeting applicable National Fire Protection Association standards and buildings with a needed fire flow in excess of 3,500 gpm. ISO individually grades the protection of buildings with a needed fire flow in excess of 3,500 gpm and their public protection classification may differ from that of the community



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providing their fire protection.

The ISO report for the City of Bloomington was completed in late 1996, with the City receiving the results in 1997. The results indicated that the City of Bloomington's public protection classification is Class 4. Bloomington received a total credit of 60.10% out of a possible 100%. The Water Supply portion of the rating received 26 points out of possible 40 points and the Fire Department received 34 points out of 60 points. To receive a Class 3 rating, both the Water Supply and Fire Department would need to increase by about 2 and 8 points, respectively for a total of 70 points. The current overall rating was reduced by 2.6 points because of the divergence between the Water Supply and Fire Department. To be classified as a Class 1, the City would need to have a total credit of 90% or more. This classification applies to properties with a needed fire flow of 3,500 gpm or less.